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NAVORD REPORT 4491

STATIC AND DYNAMIC STABILITY TESTS OF A PROPOSED VERSION OF THE GIMLET ROCKET (U)

24 NOVEMBER 1958

U. S. NAVAL ORDNANCE LABORATORY

WHITE OAK, MARYLAND

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Aerodynamics Research Report 382

STATIC AND DYNAMIC STABILITY TESTS OF A PROPOSED VERSION OF THE GIMLET ROCKET

Prepared by:

I. Shantz
F. J. DeMeritte

ABSTRACT: Presented in this report are the static stability and pitch damping results obtained in an investigation of a proposed version of the Gimlet Rocket. This investigation was performed at subsonic and supersonic speeds in the Aeroballistics Tunnel No. 1.

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

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This is a report on an investigation to determine the static and dynamic stability of a proposed version of the Gimlet Rocket. The investigation was performed at the request of the Naval Ordnance Test Station (reference (a)) under task number 103-666/64016/03040.

MELL A PETERSON
Captain, USN
Commander

R. KENNETH LOBB
By direction

Table of Contents

Illustrations

STATIC AND DYNAMIC STABILITY TESTS OF A PROPOSED VERSION OF THE GIMLET ROCKET

INTRODUCTION

1. The Gimlet Rocket is a two-inch diameter rocket fired from an airplane. The rocket is being developed by the Naval Ordnance Test Station for the Bureau of Ordnance.

2. The rocket is stored aboard the airplane in a tube. The four fins are folded aft of the rocket, upon launching the fins open and lock into place.

Symbols

A	model reference cross-sectional area
c.g.	center of gravity (see Figure 3)
C_A	axial force coefficient (F_A/qA)
C_N	normal force coefficient (F_N/qA)
C_O	pitching moment coefficient referred to base of model (M_O/qAd)
$C_{M_q} + C_{M_{\dot\alpha}}$	aerodynamic damping coefficient
d	model reference diameter: (0.75 in.) static model and (0.437 in.) damping model
F_A	axial force (lbs)
F_N	normal force (lbs)
I	transverse moment of inertia about the center of gravity (slugs-ft^2)
K_H	ballistic damping coefficient ($\frac{\mu}{\rho V d^4} - \pi/16(C_{M_q} + C_{M_{\dot\alpha}})$)
ℓ	model length
M	Mach number
M_O	pitching moment referred to base of model (in.-lbs)
q	dynamic pressure (psia)
Re	Reynolds number based on model length
t	time (seconds)
V	velocity (ft/sec)

α	angle of attack in pitch plane (degrees)
ϕ	angle of roll (degrees)
ρ	air density (slugs/cu.ft.)
u	damping coefficient $(-2I(\ln \alpha/\alpha_o)/\Delta t)$

Nomenclature

B	Body alone
BF	Body fin

Models and Balances

3. The ~~models~~ were designed and manufactured at the Naval Ordnance Test Station. The static model was used with an NOL designed and manufactured internal strain-gage balance. The damping model was dynamically balanced about the full-scale center of gravity. The location of the center of gravity of the rocket is different for the "loaded" and the "burned out" condition. Damping models simulating each of the conditions were built. The damping model was too small for ball bearings so the shaft through the center of gravity slid on a teflon insert in the body. The model was free to rotate in the pitch plan about the center of gravity.

4. The damping data are obtained by having the model mounted in the wind tunnel, rotating the model slowly, and starting the wind tunnel. The resulting damping motion is photographed using a 16 mm movie camera.

5. Figure 1 is a photograph of the static model with fins, while Figure 2 is a photograph of the static model without fins. Figure 3 is a sketch of the Gimlet model showing pertinent dimensions.

Data and Data Reduction

6. The static stability data are presented in Figures 4 through 10. The data are plotted as C_N versus α and C_Q versus α for Mach numbers of 0.78, 0.94, 2.15, 2.48 and 3.22. Axial force data were obtained at Mach number 2.15 and are plotted as C_A versus α. Pitching moment coefficients are referred to the base of the model.

7. The damping data are plotted as $C_{M_q} + C_{M_{\dot{\alpha}}}$ versus M in Figure 11 for Mach numbers 0.93, 1.56, 1.75, 2.15, 2.48, 2.87 and 3.24. The damping data were determined for the center of gravity at loaded and burned out conditions of the rocket.

8. The techniques for the reducing of the damping data are described in reference (b). Briefly, the data reduction consists of two phases, reading the film and fitting a logarithmic envelope to the data obtained from the film. From the film the angle of attack of the model is obtained for each frame of film using a comparator. The time record is obtained from the camera speed (64 frames per second). The angular deflection plotted against time yields a damped sine motion. The envelope of the motion is faired. In true harmonic damping, this envelope would be of the form $\alpha = \alpha_o e^{-\mu t/2I}$.

9. The static data are recorded with the ADAPS (reference (c)) and the data are reduced using an IBM 650 machine. The strain-gage techniques are explained in reference (d) and the data reduction equations are listed in reference (e).

References

(a) Okauchi, K., Wind-Tunnel Request (WTR 300 and WTR 325) (Unclass) 1956

(b) Shantz, I., and Groves, R. T., "Subsonic Damping-in-Pitch Measurements of the EX-10, EX-30, and 6" Test Vehicle", NAVORD Report 4025, (Conf.) Unpublished AD-303075

(c) Gilbert, B. D., "Automatic Data Processing System (ADAPS) for the Supersonic Wind Tunnels", NAVORD Report 2813, (Unclass) 1953 AD-123067

(d) Shantz, I., Gilbert, B., and White, C., "NOL Wind-Tunnel Internal Strain-Gage Balance System", NAVORD Report 2972, (Unclass) 1955

(e) DeMeritte, F. J., Gilbert, B. D., and White, C. E., "Contract Wind-Tunnel Testing", NAVORD Report 3562, (Unclass) Unpublished

L=0

TABLE I

Test Section Conditions for Static Test

M	Figure No.	Configuration	ø (degrees)	q (psia)	Re x 10^{-6}
0.78	4	BF	0	4.00	5.8
0.78	4	B		4.02	5.9
0.94	5	BF	0	4.91	6.4
0.94	5	B		4.92	6.4
2.15	6	BF	0	4.63	5.2
2.15	7	BF	45	4.63	5.2
2.15	8	B		4.63	5.2
2.48	9	BF	0	3.75	4.4
2.48	9	B		3.75	4.4
3.22	10	BF	0	2.07	3.1
3.22	10	B		2.07	3.1

B = body alone (ℓ = 16.667 in.)

BF = finned body (ℓ = 16.657 in.)

TABLE II

Test Section Conditions for Damping Test

M	q (psia)	Re x 10^{-6}
0.93	4.73	3.7
1.56	6.1	3.7
1.75	5.8	3.5
2.15	4.76	2.9
2.48	3.78	2.6
2.92	2.70	2.1
3.24	2.03	1.8

Body length 9.716 in.

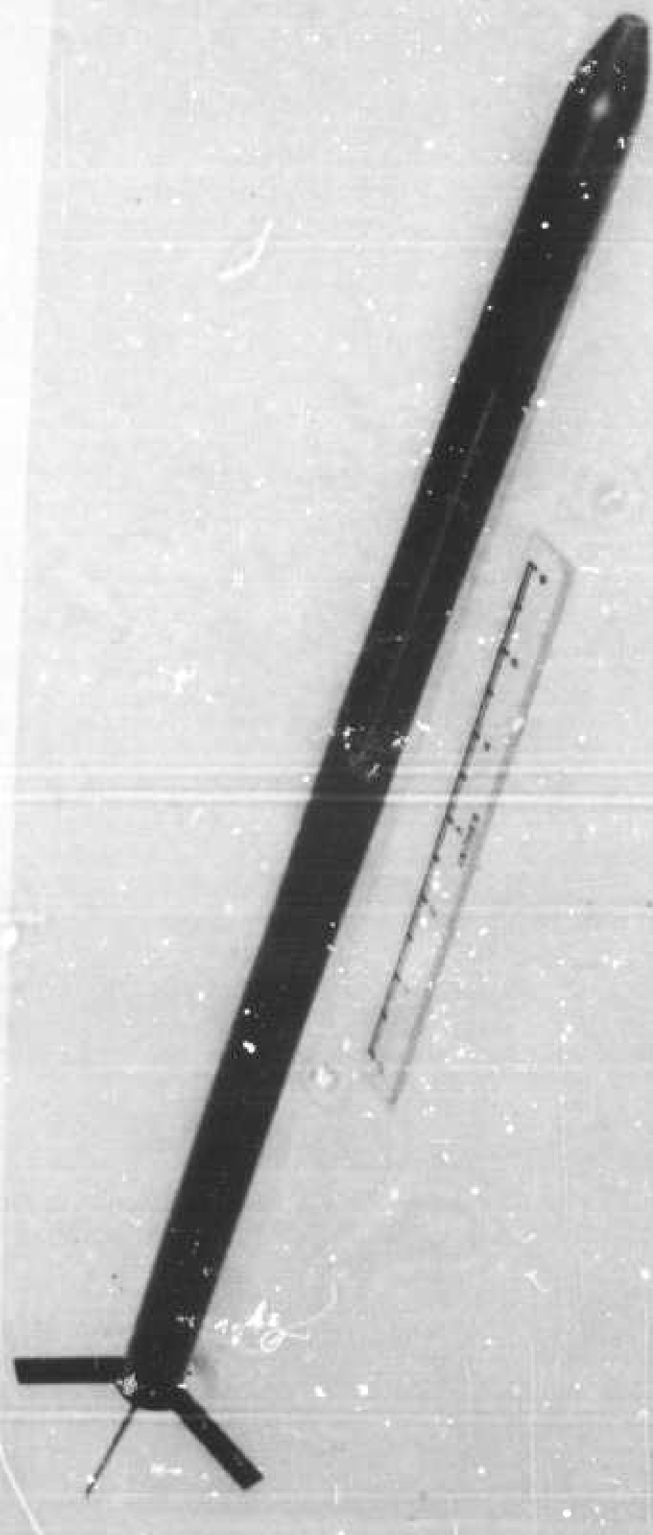


FIG. I STATIC MODEL

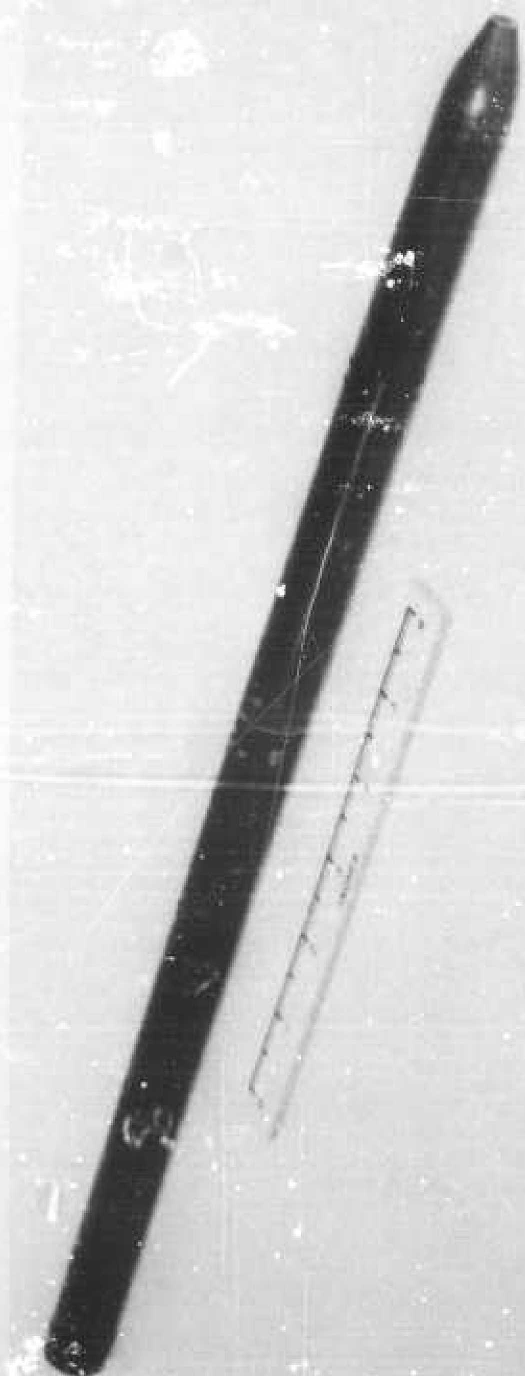


FIG. 2 STATIC MODEL
BODY ALONE

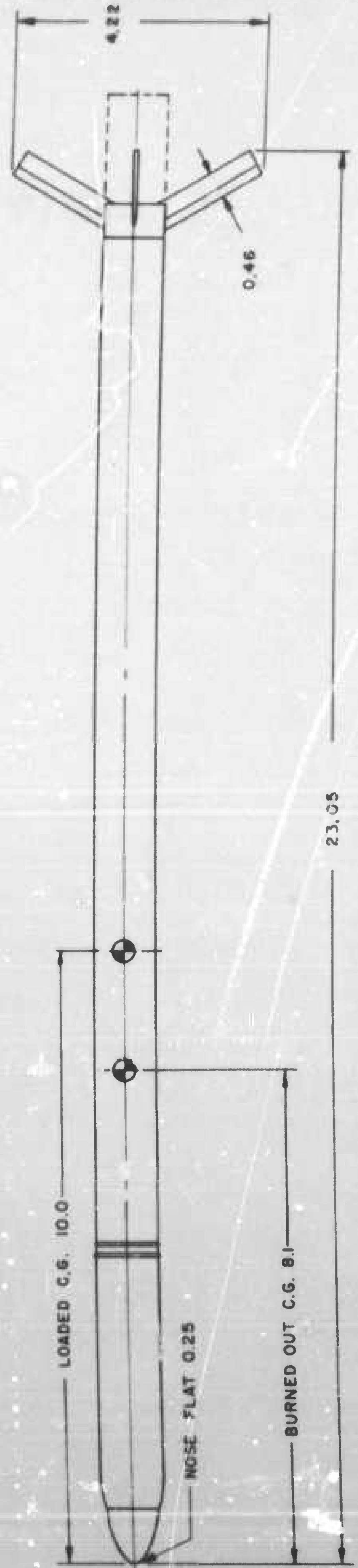


FIG. 3 GIMLET MODEL
(ALL DIMENSIONS IN CALIBERS)

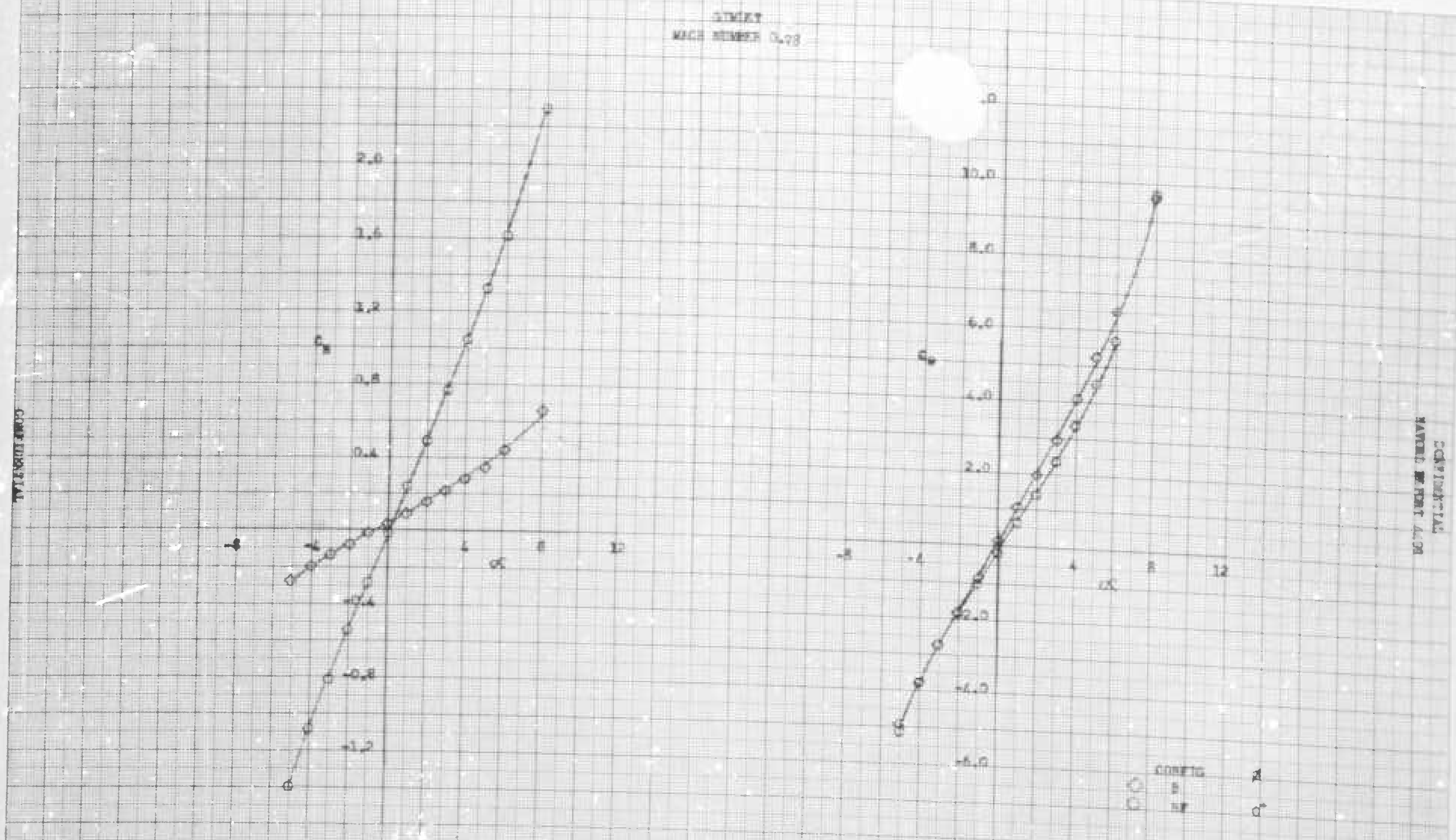

MACH NUMBER 0.78
C_N
2.0
1.6
1.2
0.8
0.4
-0.4
-0.8
-1.2
-8
-4
4
8
12
α
C_m
10.0
8.0
6.0
4.0
2.0
-2.0
-4.0
-6.0
CONFIG
B
BF

FIG. 4

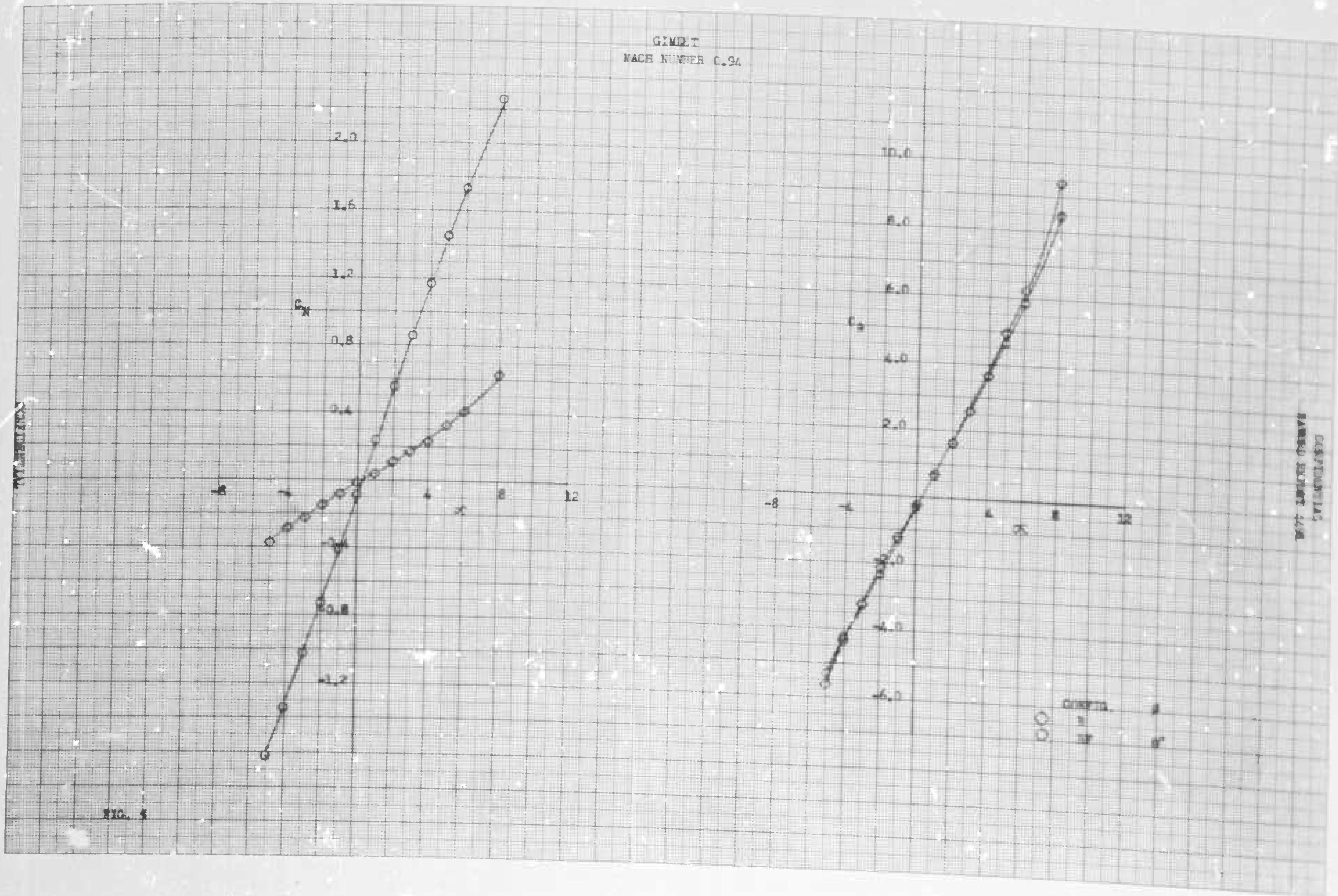

GIMLET
MACH NUMBER 0.94
C_N
2.0
1.6
1.2
0.8
0.4
-0.4
-0.8
-1.2
-8
-4
4
8
12
α
C_m
10.0
8.0
6.0
4.0
2.0
-2.0
-4.0
-6.0
CONFIG. β
X
XF 0°

FIG. 5

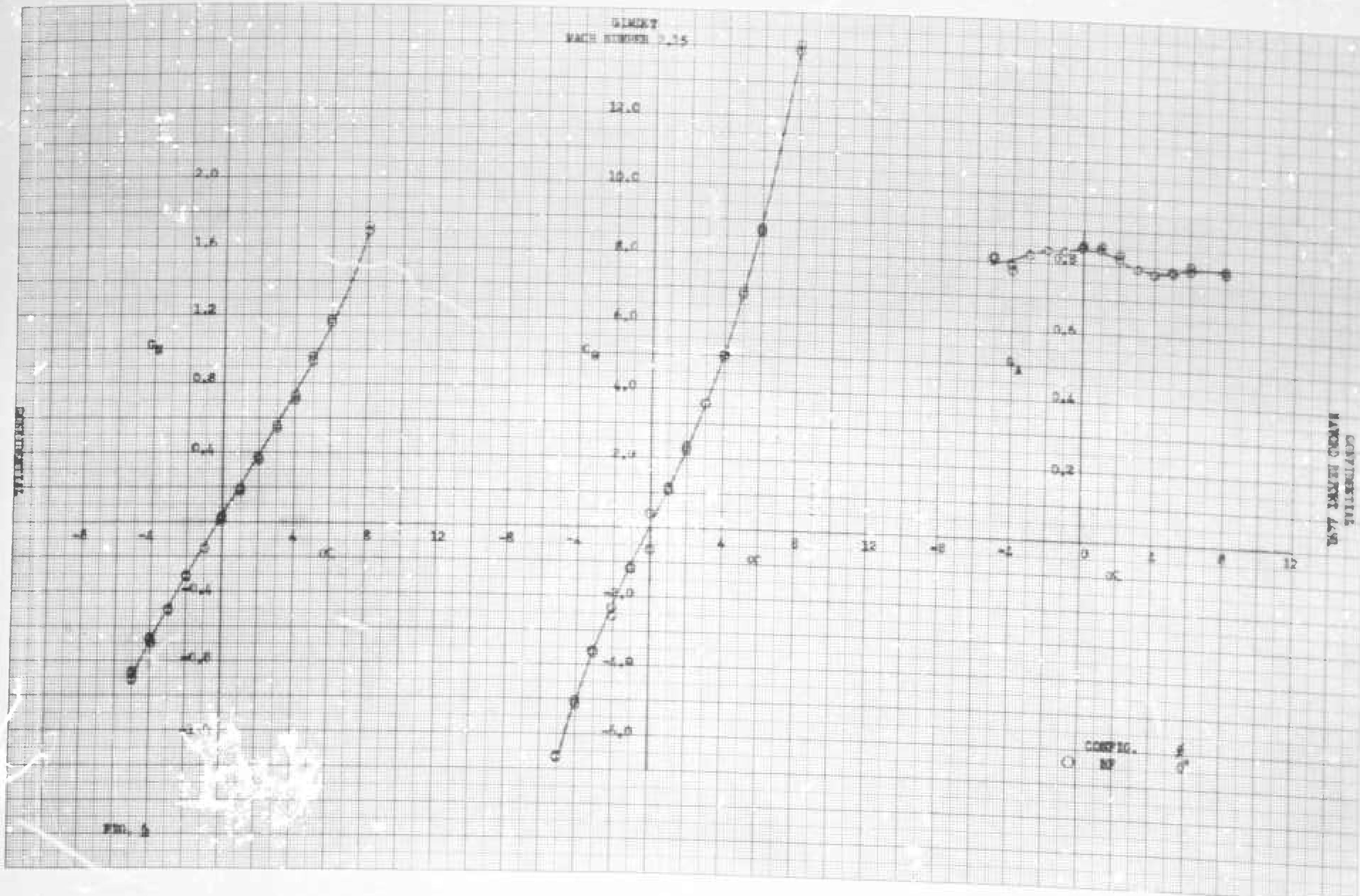


FIG. 5

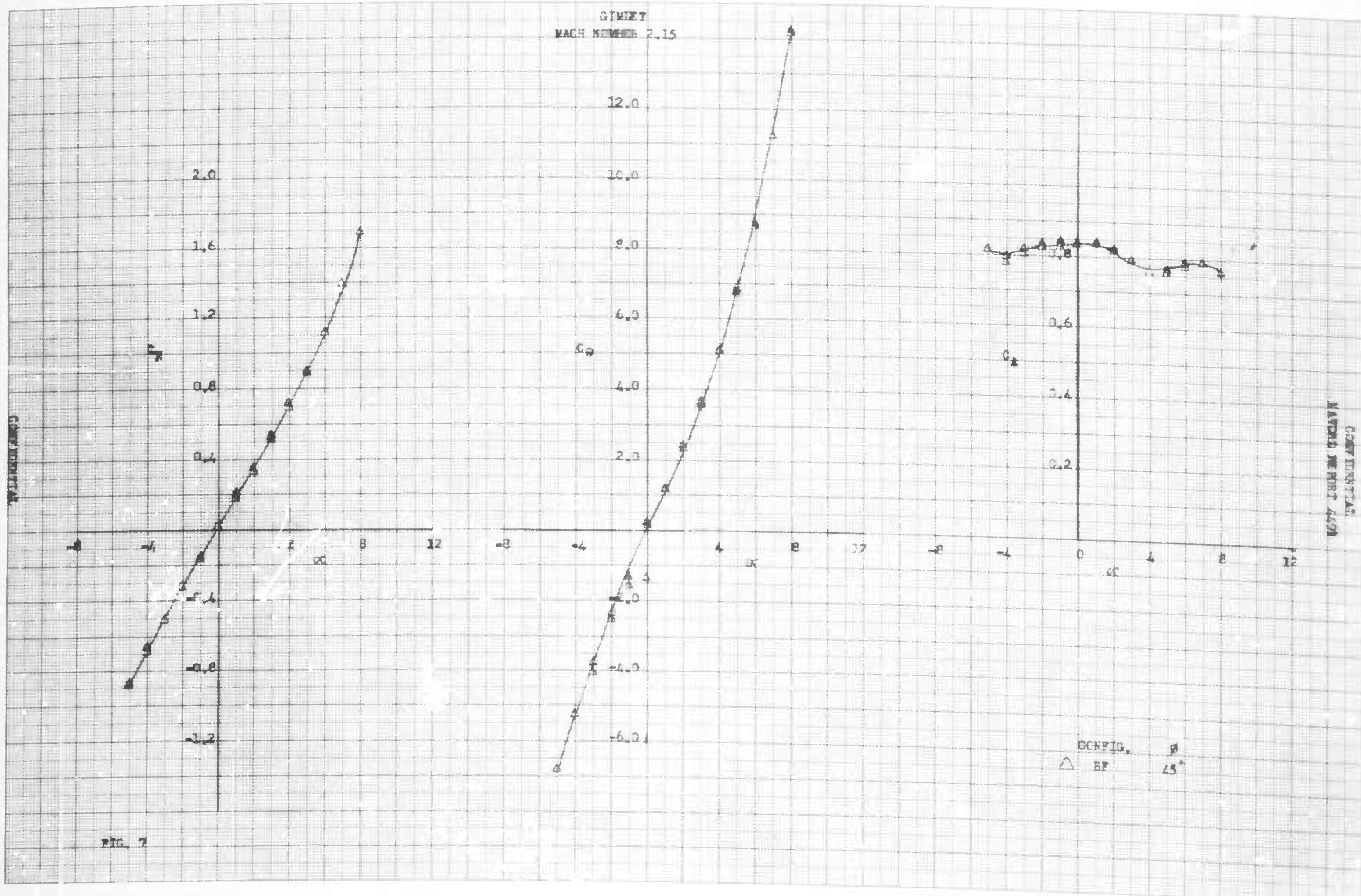
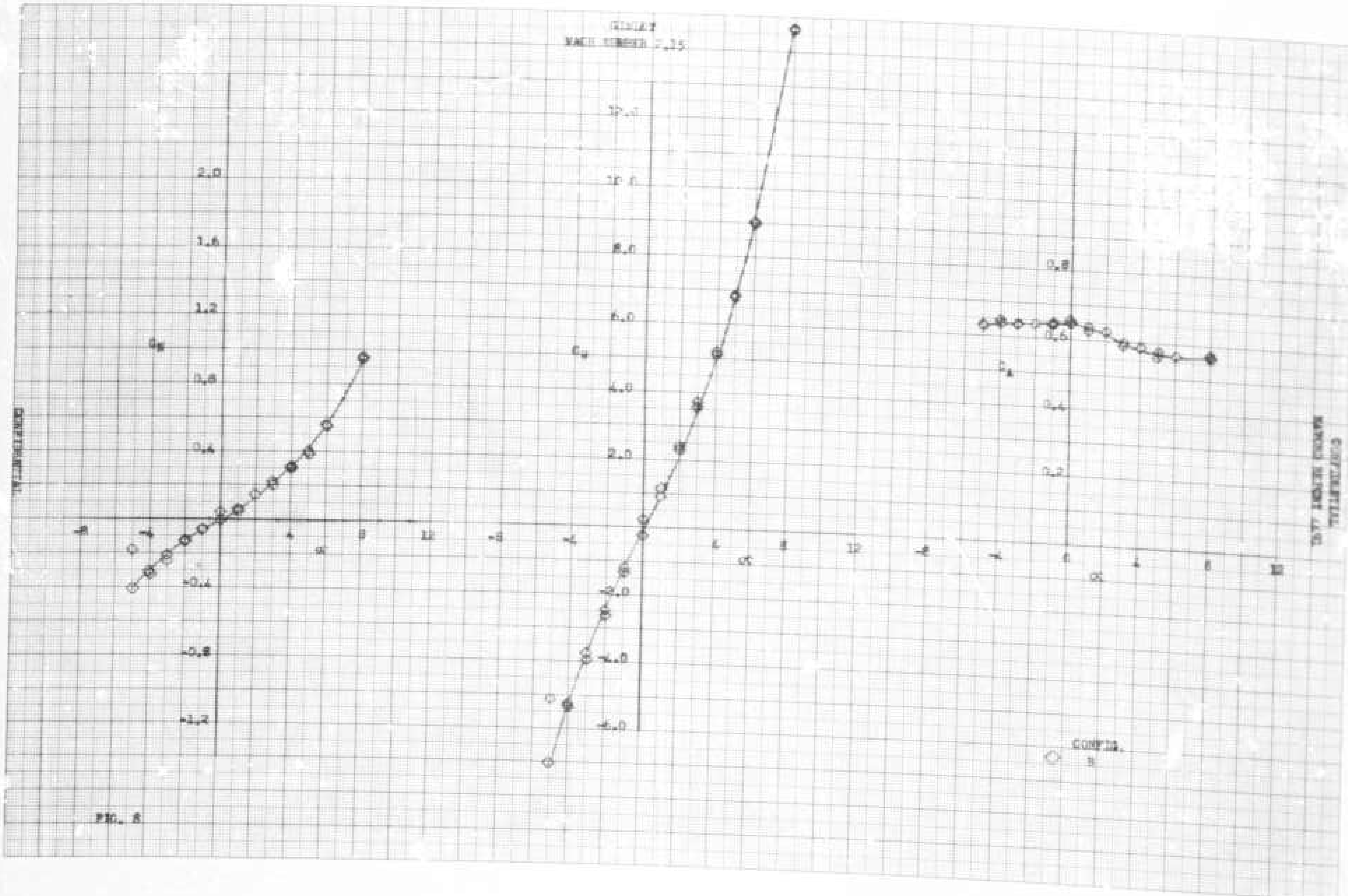


FIG. 7



C_N
2.0
1.6
1.2
0.8
0.4
-0.4
-0.8
-1.2
-8
-4
4
8
12
α
C_m
12.0
10.0
8.0
6.0
4.0
2.0
-2.0
-4.0
-6.0
0.8
0.6
0.4
0.2
C_A
CONFIG.
B

FIG. 8

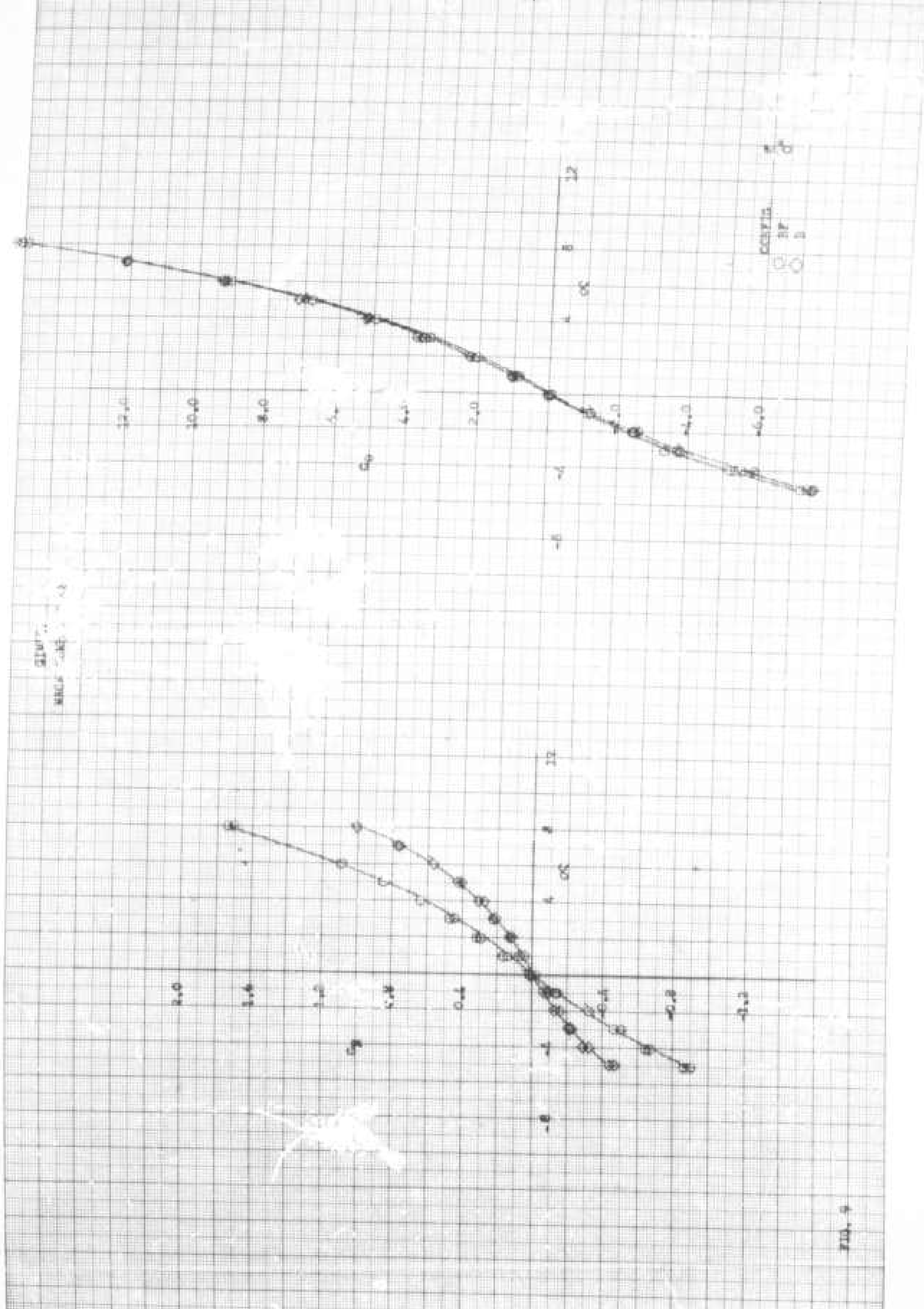


FIG. 9

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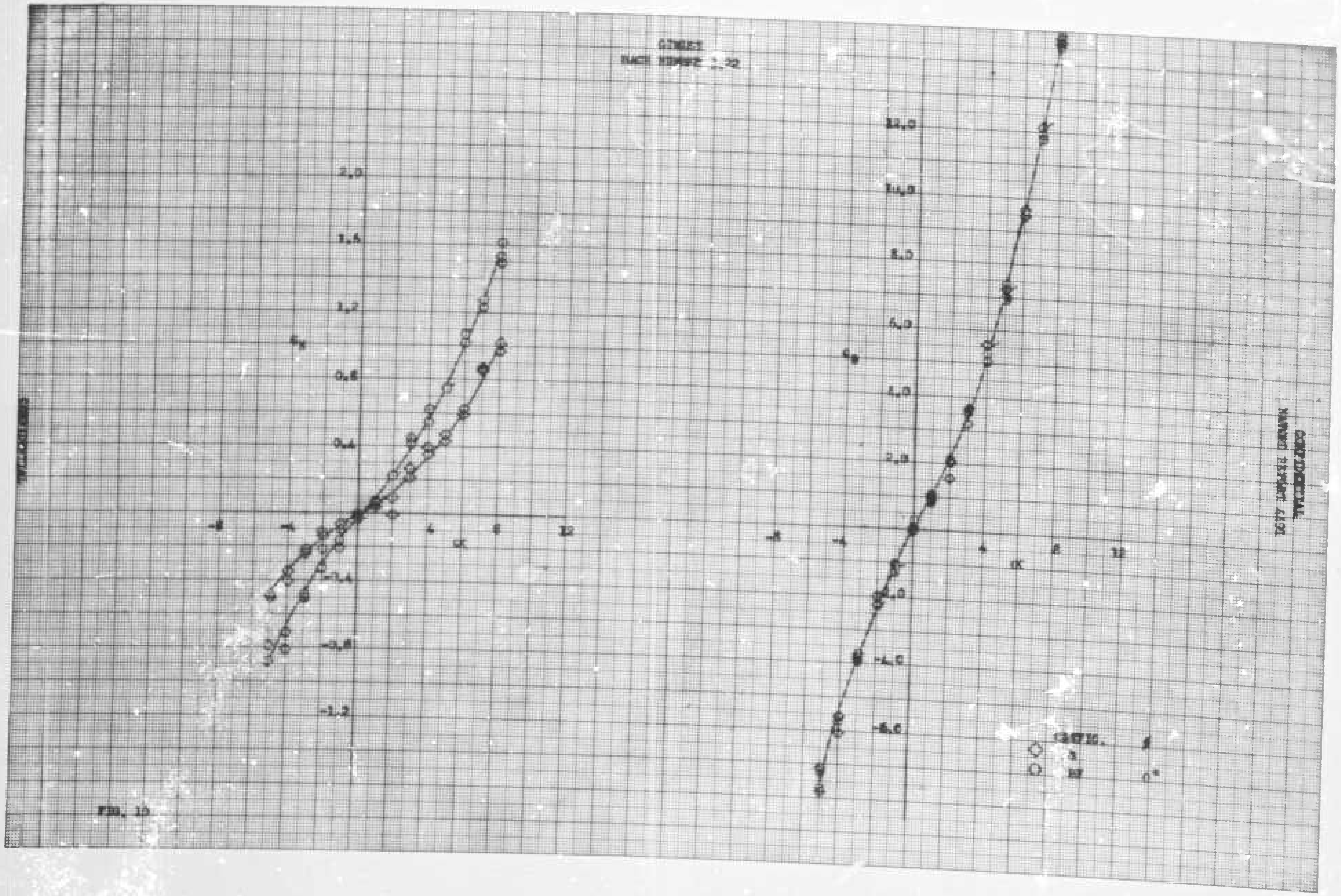

FIG. 10

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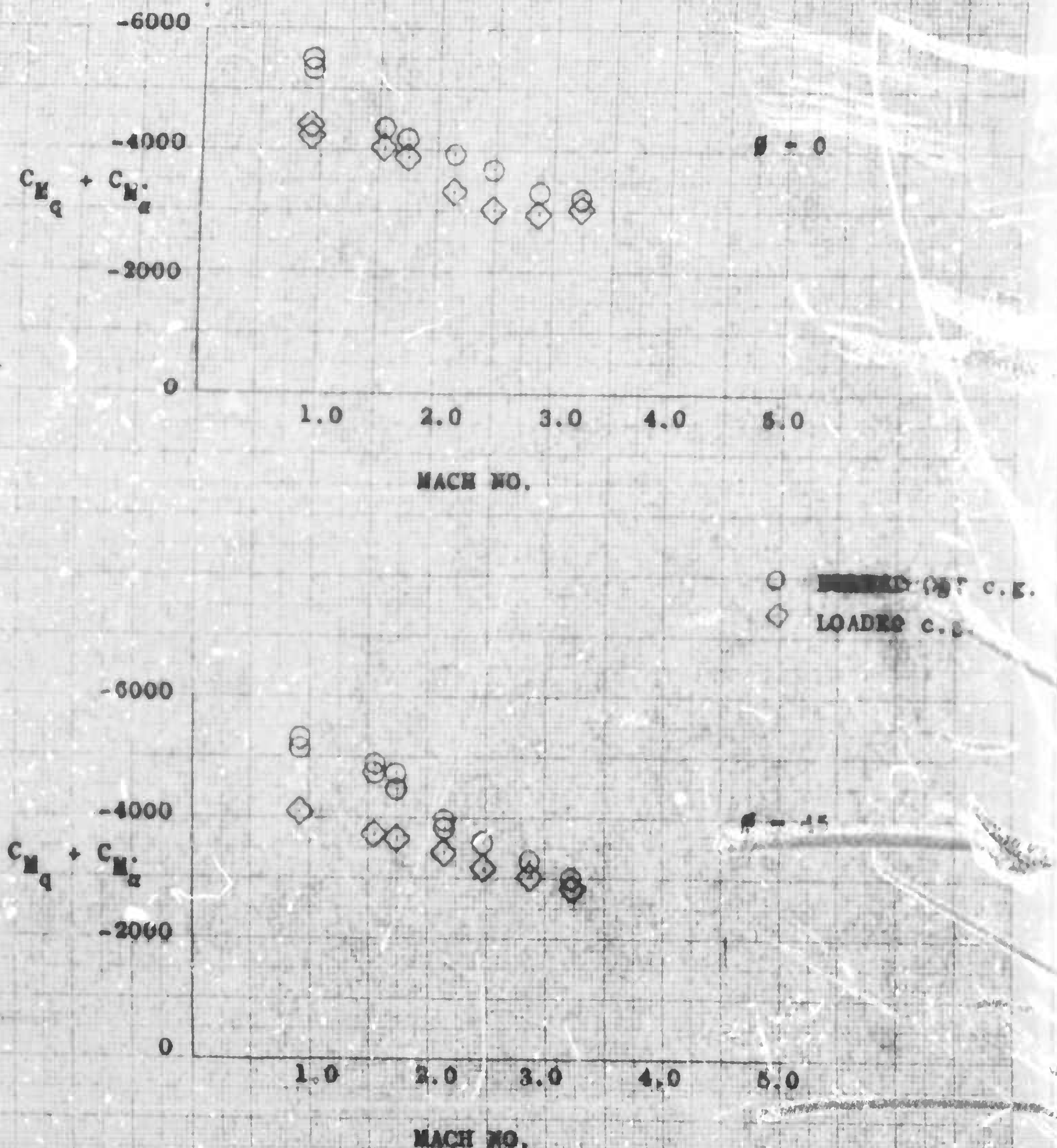
GIMLET


-6000
-4000
-2000
0
$C_{M_q} + C_{M_{\dot{\alpha}}}$
1.0
2.0
3.0
4.0
5.0
MACH NO.
$\phi = 0$
[redacted] c.g.
LOADED c.g.
$\phi = 45$